PROBING THE DEPTHS

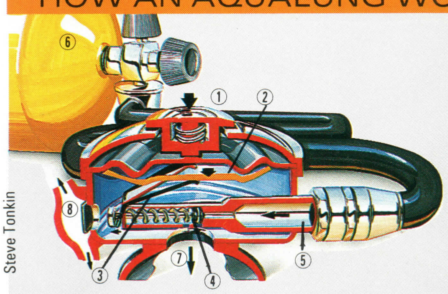
Rex Features

SPECIALIST DIVING EQUIPMENT can take Man to greater depths than ever before – and in relative safety. Even the idea of an entire city beneath the waves is by no means beyond the realms of possibility.

A diver must keep warm to stay alert. If the body gets too cold, concentration wanders and more air is used up. So divers often wear wet suits made of foam neoprene (synthetic rubber) – even in quite warm waters.

A small quantity of water seeps into the suit and becomes trapped between the material and the diver's skin. The water is quickly warmed by the heat of the body, and air bubbles in the neoprene act as a heat insulator. It is like swimming in a lukewarm bath!

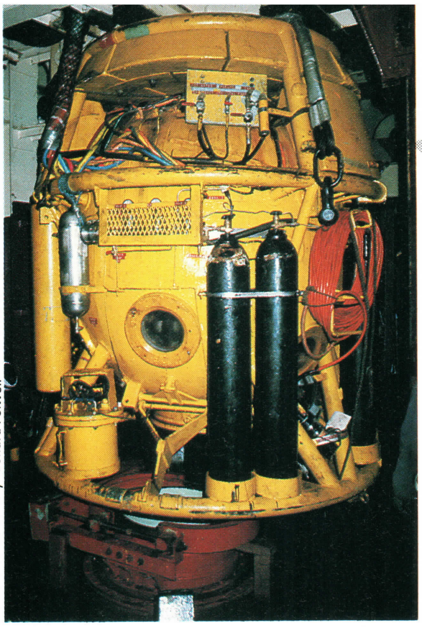
HOW AN AQUALUNG WORKS



Steve Tonkin

Water enters the demand valve (1) and presses on a rubber diaphragm (2). An attached lever (3) controls a valve (4) to admit air (5) from the cylinder (6). This arrangement keeps the air supply to the mouthpiece (7) at the right pressure – the same pressure as the surrounding water. Used air is expelled through a valve at the side (8).

Patrick Baker/Bruce Coleman Ltd


Science Photo Library/Richard Folwell

***A pressurized North Sea** diving bell normally receives air through the umbilical when submerged. For use in emergencies, the bell carries air cylinders on the outside.*

Just amazing!

BUBBLING BLOOD

IF YOU DIVE BELOW A CERTAIN DEPTH AND SURFACE TOO QUICKLY, THE BLOOD IN YOUR VEINS CAN START TO BUBBLE, CAUSING A BAD CASE OF THE BENDS!


Paul Raymonde

In colder water, a dry suit is used. This is completely watertight and has a fleecy 'woolly bear' undersuit for extra insulation. Both wet and dry suits tend to keep the diver afloat, so a weight belt is worn in order to keep the diver down.

When the diver enters the water, pressure is exerted on his body. Just a couple of metres below the surface, the pressure will cause a tightness around the face as air cavities in the head are squeezed. And it would be impossible to breathe through a snorkel tube two metres long because the lungs could not expand against the extra pressure under water. This is why divers use a compressed air supply with a device that regulates the pressure to match that of the surrounding water.

The most common form of scuba (self-contained underwater breathing apparatus) is the aqualung. It allows a diver to swim to depths of 50 metres for up to an hour.

Cylinders of compressed air (at a pressure over 200 times that of the air around us) are carried on the back. A flexible hose connects the cylinders to a mouthpiece. Whenever the diver inhales, a device called a demand valve allows air to flow from one of the cylinders.

The equipment may look heavy and clumsy, but in the water it is almost weightless and the diver retains freedom of movement.

Avoiding the bends

As the diver goes deeper, the water pressure and the pressure of the air breathed become greater. If this air pressure is released too quickly by the diver surfacing too fast, the expanding air may damage the lungs and form bubbles in the blood. This effect, called air embolism, restricts the blood flow and may cause injury or even death.

Fast surfacing may also cause decompression sickness, usually called 'the bends'. This occurs when bubbles of nitrogen gas from the air form in the blood, and is as dangerous as air embolism. To avoid these dangers, the rate of decompression (the change from high- to low-pressure conditions) must be carefully controlled.

The narks

Another problem of working at great depths is that breathing the high-pressure air mixture of nitrogen and oxygen could result in nitrogen narcosis (the 'narks') – a sort of drunkeness. Nitrogen makes up four-fifths of the air we breathe, and too much could be absorbed by the blood under these conditions. The nitrogen acts like a drug, causing muddled thinking, disorientation and, sometimes, panic.

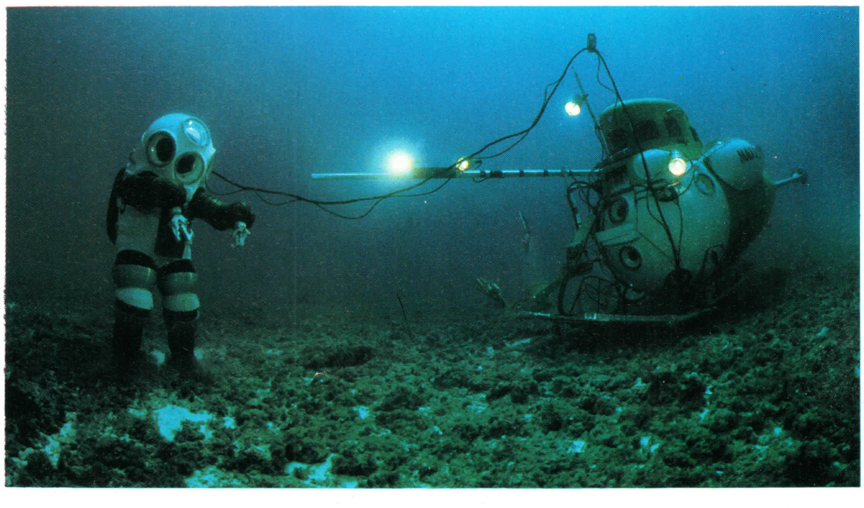
To avoid this, the nitrogen is replaced by helium gas. The helium-oxygen mixture is known as heliox. Helium has the comical side-effect of making even the gruffest voice sound like Donald Duck, so electronic speech decoders are used to understand the diver's words.

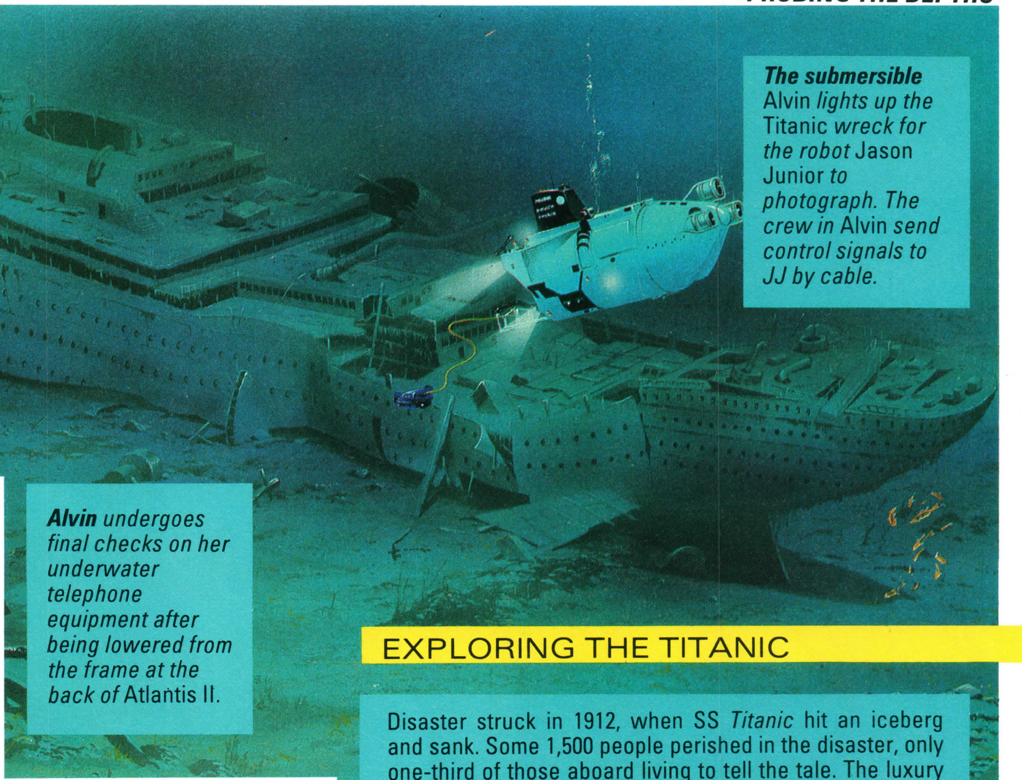
Because the air is so highly compressed, far more is used for each breath. A cylinder that lasts for 30 minutes at 10 metres would not last

ATMOSPHERIC DIVING SUIT

Osel Group

***Like an astronaut** exploring the Moon's surface, a diver in an atmospheric diving suit searches the sea bed, fully protected from his hostile surroundings.*


Planet Earth Pictures/Images Inc, Charles Nicklin



The submersible *Alvin lights up the* Titanic *wreck for the robot* Jason Junior *to photograph. The crew in* Alvin *send control signals to JJ by cable.*

EXPLORING THE TITANIC

Disaster struck in 1912, when SS *Titanic* hit an iceberg and sank. Some 1,500 people perished in the disaster, only one-third of those aboard living to tell the tale. The luxury liner lay undisturbed on the sea bed until its discovery in 1985. One year later, the ship *Atlantis II* took a team to explore the wreck using the manned submersible *Alvin. Jason Junior,* an underwater robot affectionately known as 'JJ', probed the wreck to photograph its interior.

Bill Donohoe

Gamma/Frank Spooner Pictures

Alvin *undergoes final checks on her underwater telephone equipment after being lowered from the frame at the back of* Atlantis II.

The deck *of the* Titanic *has a mystical eerie appearance after a lifetime on the sea bed. Corrosion and plant life colour the rusting steel structure.*

three minutes at 200 metres. Although deep-sea divers carry a cylinder in case of emergency, their main air supply comes through a tube from the surface.

As well as air, hot water can be supplied to heat the diver's suit and a telephone link provided for communication with the surface.

Saturation diving

After a few minutes at 200 metres, a diver would need hours of decompression. So where a diver is required to spend a long time in very deep waters, it is more practical – and safer – to employ saturation diving. This means that the body becomes saturated with breathing gas at high pressure until no more can be absorbed. When he is not working, the diver lives in a sealed chamber, which has been 'blown down' to a pressure corresponding to the working depth.

To enter the water, the diver transfers – still under pressure – to a diving bell. This bell is detached from the chamber and lowered to the seabed or working site, where the diver leaves through a bottom hatch. After a period of work, the diver re-enters the bell and is hoisted back to the chamber.

Divers can work like this for weeks or even months. Decompression does not begin until the end of the whole project and can take several days to complete.

One outfit that has overcome the problem of water pressure and decompression is the 'atmospheric' diving suit. The JIM – named after Jim Jarratt, the mechanic who tested the prototype in the 1930s – is capable of going to depths of over 500 metres. Inside, the diver remains safe and dry, breathing air at normal atmospheric pressure.

The suit has limbs with watertight flexible joints that allow the diver to move and work quite freely. It is just like an underwater observation chamber with arms and legs.

Submersibles are another alternative for deeper exploration. These miniature submarines are capable of carrying a small, but expert crew to depths of 4,000 metres.

Submersibles are taken to the work site on a support ship and launched – usually over the stern – from a large gantry. Mobile submersibles have thrusters (ducted propellers), which are turned by battery-powered electric motors. These submersibles cover short distances at only a few knots.

Submersibles can also be operated from the surface. A remotely-operated vehicle (ROV) usually has a frame that supports motors and thrusters, buoyancy devices, and masses of manipulating and sensing equipment – effectively the eyes, ears and hands of the vehicle.

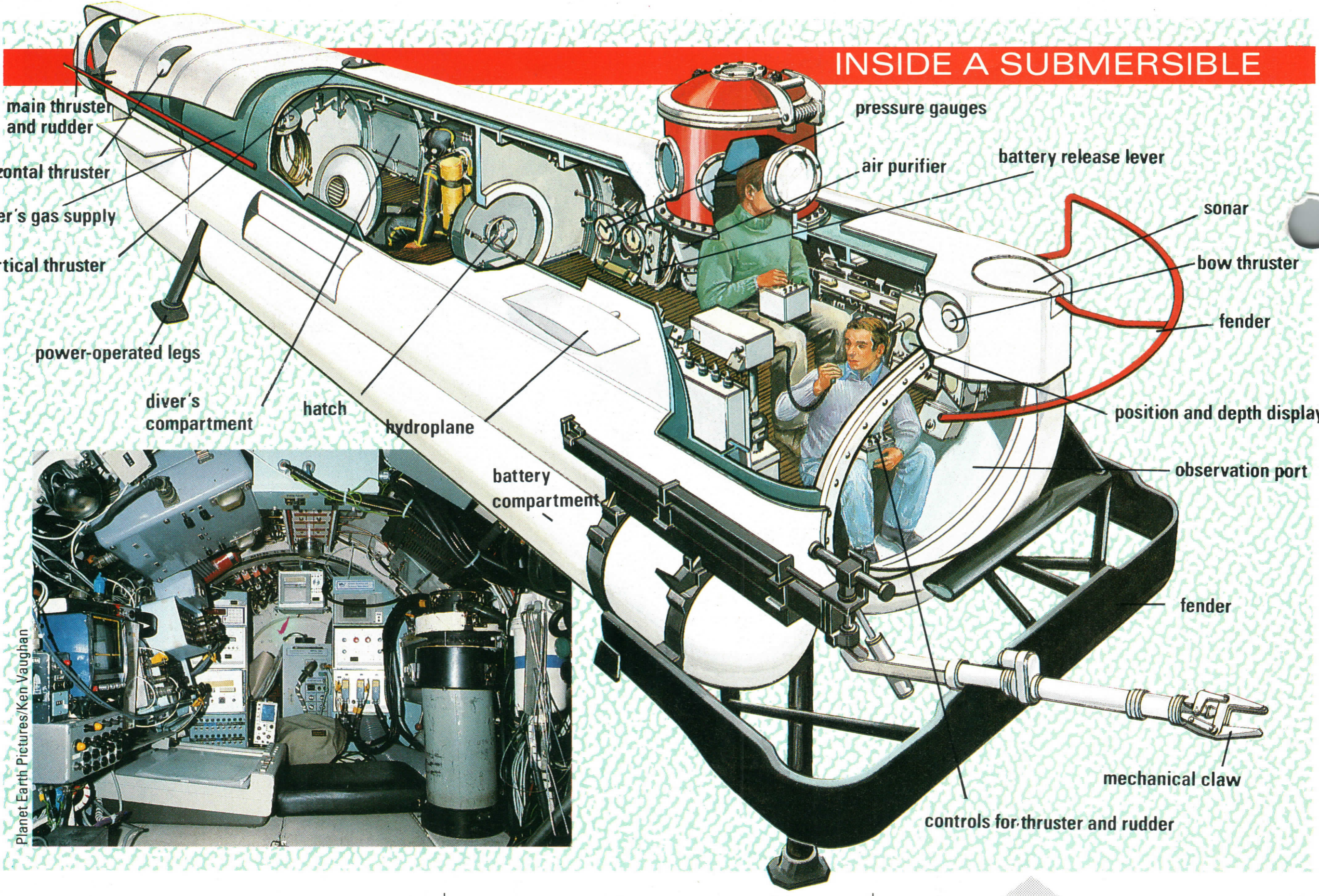
This type of underwater robot is tethered to the surface by an umbilical cable that carries power, navigational information, command signals and television pictures from the watertight cameras on board. The operator simply controls the ROV using a joystick.

Deep water work

The ROV's lifeline – the umbilical – becomes its undoing for deep-water work. Despite the use of ultra-slender optical-fibre cables for video and command links, umbilicals are quite heavy because they also carry high-current electrical supplies to the propulsion motors. Beyond depths of 2,000 metres, the bulk and weight of the umbilical becomes unmanageable.

However, in 1985, 180 km off south-west Ireland, a Scarab II ROV

INSIDE A SUBMERSIBLE



located the wreckage of an Air India jumbo jet. Later, vital clues were recovered from the sea-bed at a depth of over 2,000 metres in one of the most ambitious ROV operations ever undertaken.

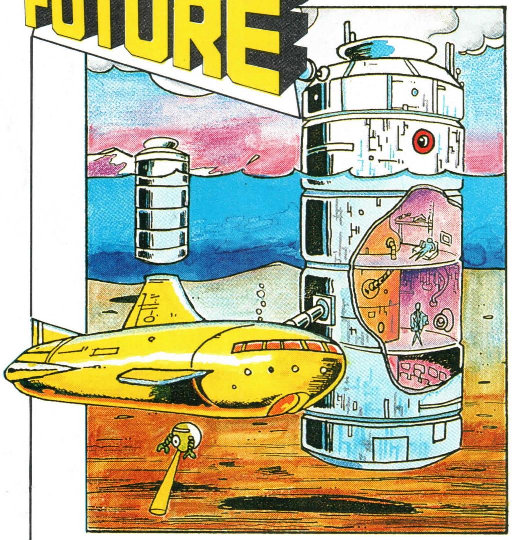
Perhaps the most futuristic submersible is *l'Argyronete* planned for the French 'Saga' project, to locate oil and gas under the sea-bed beneath the polar ice-caps. The vehicle will carry a crew of six, and a team of divers operating from a pressurized 'lock-out' chamber. But travelling under ice-caps means the vessel will be away from its support ship for a day or more, ruling out rechargeable batteries for propulsion. Instead, Stirling engines, which need no exhaust, or compact nuclear reactors, may be used.

Another pioneering idea is pleasure cruising in submersibles. In the Caribbean, up to 50 passengers can be taken on hour-long dives to 70 metres. An ROV 'flying eyeball', shows close-ups of marine life.

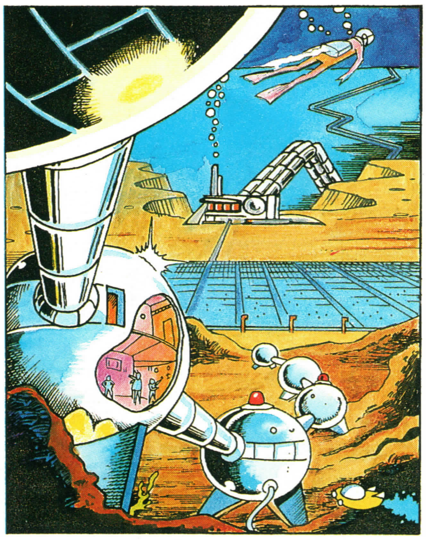
▲ ***A diver** prepares to leave his submersible through a hatch. Control and monitoring equipment inside a British Oceanics submersible (inset).*

INTO THE FUTURE

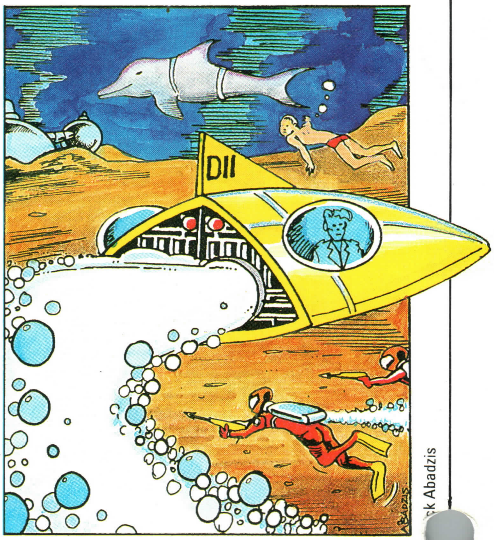
DEEP-SEA CITIES



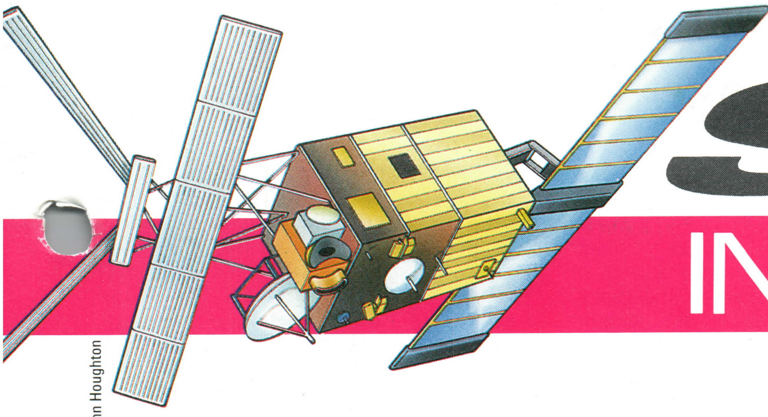
▲ *One day floating capsules may provide homes for some of the world's expanding population. Powerful engines will keep the capsules in position.*



▲ *People will work in factory units, linked to one another by sealed corridors. Hatches will allow divers access to the outside for maintenance work.*



▲ *Submersible taxis will take workers to factories. Trained dolphins may act as postmen, with armed police patrols providing protection against predators.*



John Houghton

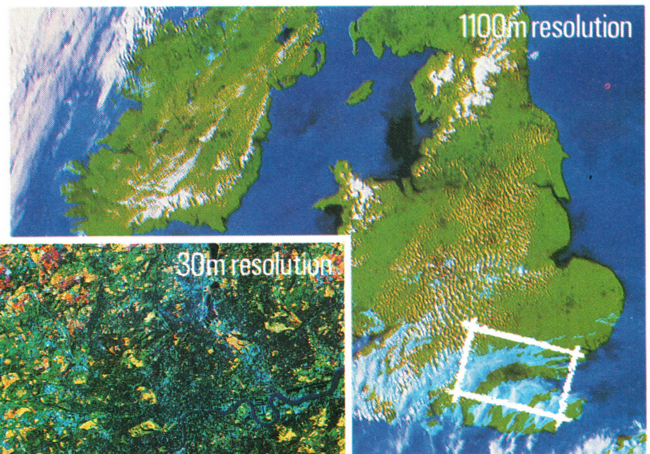
SPY IN THE SKY

- NAVIGATION
- WATCHFUL EYES
- WEATHER PREDICTION

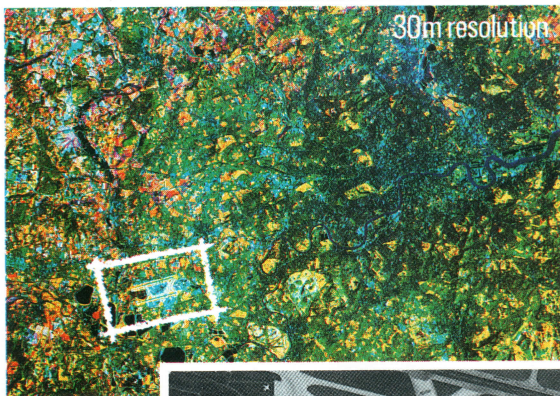
SOMEWHERE IN SECRET FILES in the United States and the CIS are pictures that, if magnified, would show your house, your family's car, and perhaps even you, walking down the street.

They were taken by spy satellites, hovering high above Earth's atmosphere, fitted with super-powerful cameras.

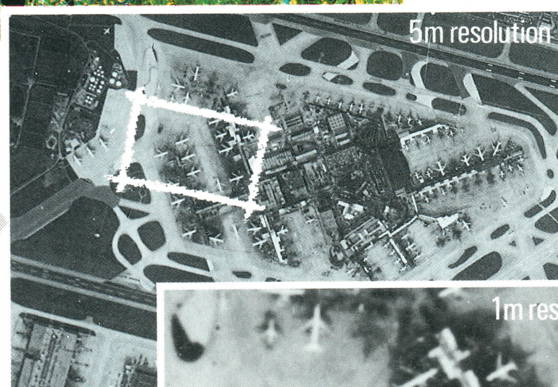
Apart from the dramatic pictures that these 'eyes in the sky' can give, they also provide other, vital data. Other spacecraft circling the Earth monitor the weather or



Daily Telegraph Colour Library



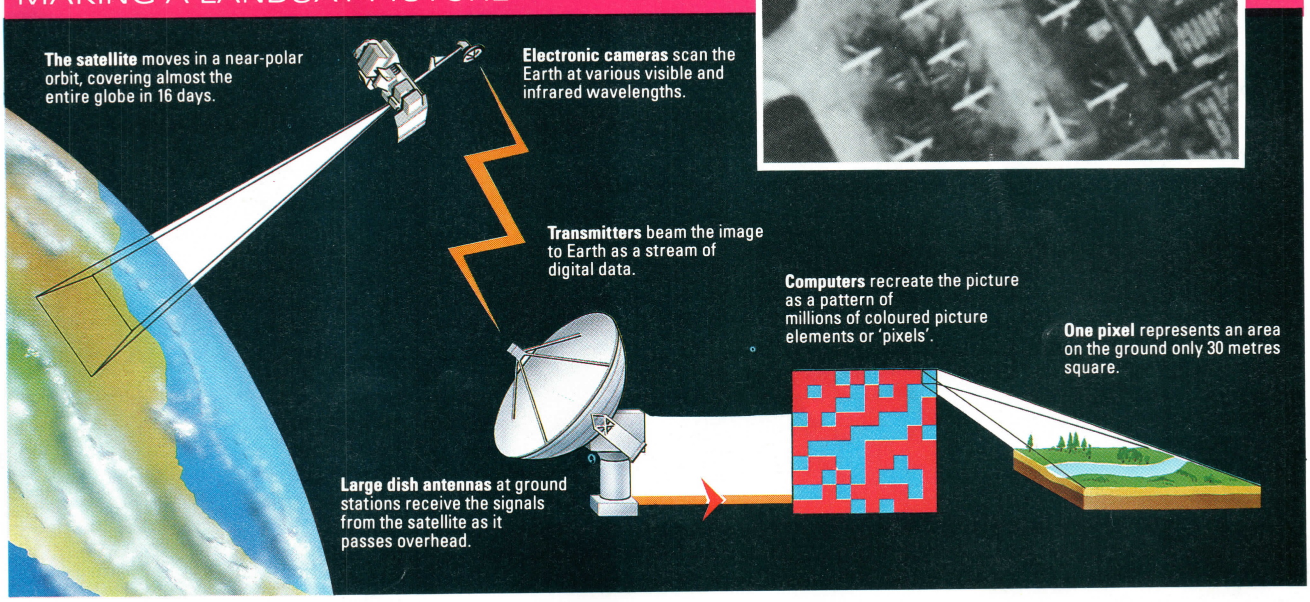
Salamander



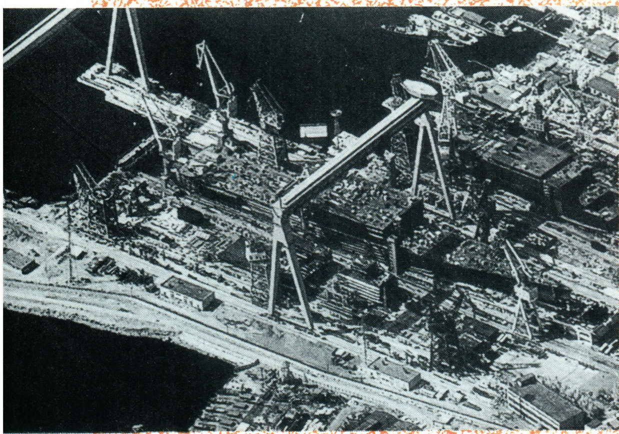
Heathrow Airport Ltd

***Satellites orbiting Earth** can produce photos of remarkable quality. (From the top) At 1100 metres resolution – a natural colour shot of Southern Britain. At 30 metres – an infra-red image of land use. Closing in further to 5 metres resolution, the layout of Heathrow Airport becomes apparent. At 1 metre resolution, individual planes can be identified on the tarmac.*

MAKING A LANDSAT PICTURE



Berry Fallon Design



Associated Press

Few things can be kept secret from the American KH-11 spy satellite that took this picture. It shows the 75,000-tonne nuclear aircraft carrier *Leonid Brezhnev* being built at a Soviet port on the Black Sea. Though the picture looks as detailed as if it were taken from a plane, the satellite was actually 250 km above the Earth's surface. It can photograph a detail as small as 30 cm across.

survey the surface for mineral wealth. Everything on our planet has its own special way of reflecting, transmitting and absorbing light. So from space a field of wheat, for instance, looks different from a field of maize, and an outcrop of iron ore looks different from one of coal.

Getting the data back

Satellites gather data with a variety of instruments — photographic cameras, TV cameras, infra-red detectors and so on. TV and radio signals are beamed down to receiving stations on the ground. Capsules containing exposed film can be returned to Earth by parachute. Or the film can be scanned electronically, and the resulting signal transmitted to Earth.

Using computers, detailed colour pictures can then be built up from the spacecraft information, allowing scientists to spot crop diseases and forest fires, search for valuable minerals, follow the movement of oil slicks that threaten to pollute beaches, and even watch the migration of animal herds.

Earth Satellite Corpn./SPL

***A Landsat** infra-red image of New York City. The Hudson River runs to the top of the image; Kennedy Airport is the light-coloured rectangular complex to the right.*

Satellites also provide early warnings of approaching blizzards, or of hurricanes as they develop out at sea and then move in toward land.

Steering by satellite

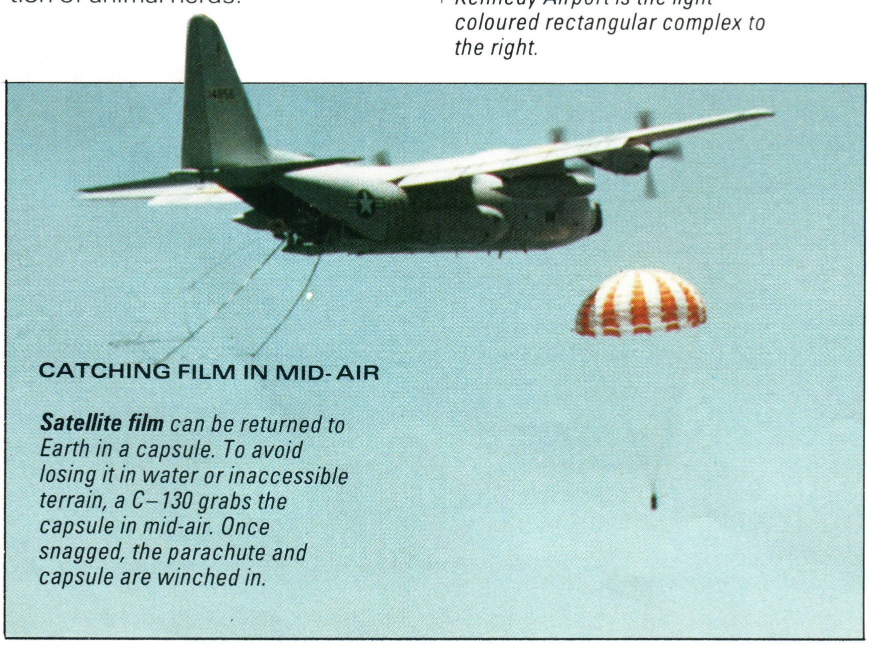
Long ago, sailors used to set their ship's course according to the position of the Sun and stars. Today, navigation satellites act as artificial 'stars' by which pilots on the sea or in the air can find precisely where they are at any instant.

Navigation satellites work by sending down radio signals that give the spacecraft's exact location in space at a given time. Ships and aeroplanes need only pick up the signals from three separate satellites to be able to work out their own position. All the necessary calculations are done swiftly by a miniature computer on the ship or aeroplane.

Even small sailing boats equipped with a proper receiver, can make use of satellite navigation. And the next step will be to develop a similar system that can work in cars and other road transport. Early in the next century it should be possible to keep track of your car's position to within 20 or 30 metres, and for a computer display inside the car to show the best route to follow to reach a particular destination.

Mission to Earth

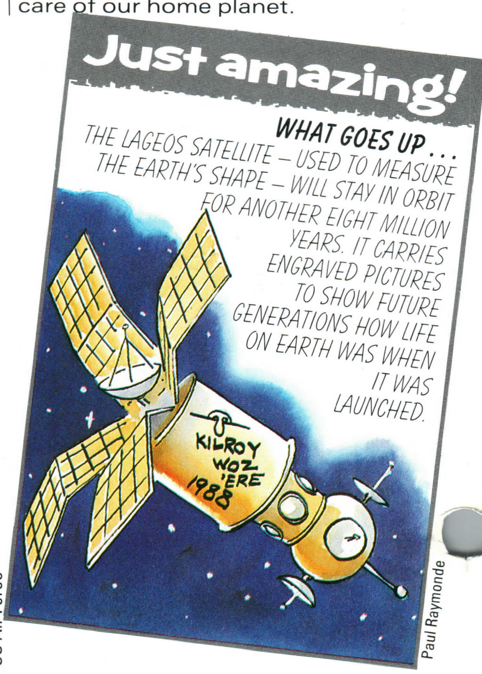
The world's major space agencies have agreed to increase their co-operation in observing Earth from space. Information from orbit will show clearly what effect the human race is having on its environment. It will allow each nation to make better use of its resources and to be warned of any impending natural or man-made disasters. Increasingly, our eyes in the sky will give us a fresh view of the Earth and the knowledge we need to take better care of our home planet.



CATCHING FILM IN MID-AIR

***Satellite film** can be returned to Earth in a capsule. To avoid losing it in water or inaccessible terrain, a C–130 grabs the capsule in mid-air. Once snagged, the parachute and capsule are winched in.*

US Air Force



Paul Raymonde

TELESCOPES FOR TOMORROW

OVER THE LAST FEW DECADES, astronomers have discovered an astonishing 'zoo' of new objects in space. There are tiny dead stars, called pulsars, spinning round dizzily and sending out narrow beams of radiation that sweep round like the beams from a lighthouse. There are blazing whirlpools of matter swirling around monstrous black holes. And there are galaxies colliding, massive stars exploding, and planets being born.

It is thanks to the most recently developed tools of astronomy that these amazing sights have been brought into clear view. By building bigger, better optical telescopes, scientists have learned very much more about the Universe as it looks in ordinary light. But just as importantly, they have extended their vision with instruments that can 'see' radio waves, x-rays, infra-red waves, and other types of invisible radiation.

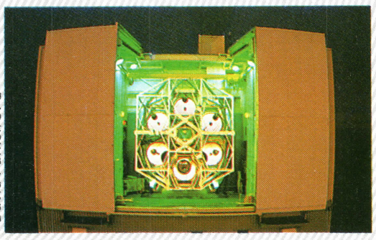
All the biggest optical telescopes in the world today use a curved mirror to gather and focus the light from distant objects. The light may be focused on to film, building up a detailed image over a period of hours. Or it may be collected by very sensitive electronic detectors that amplify even the tiniest trickle of light from a far-away object.

The Hubble Space Telescope, launched by the Space Shuttle in

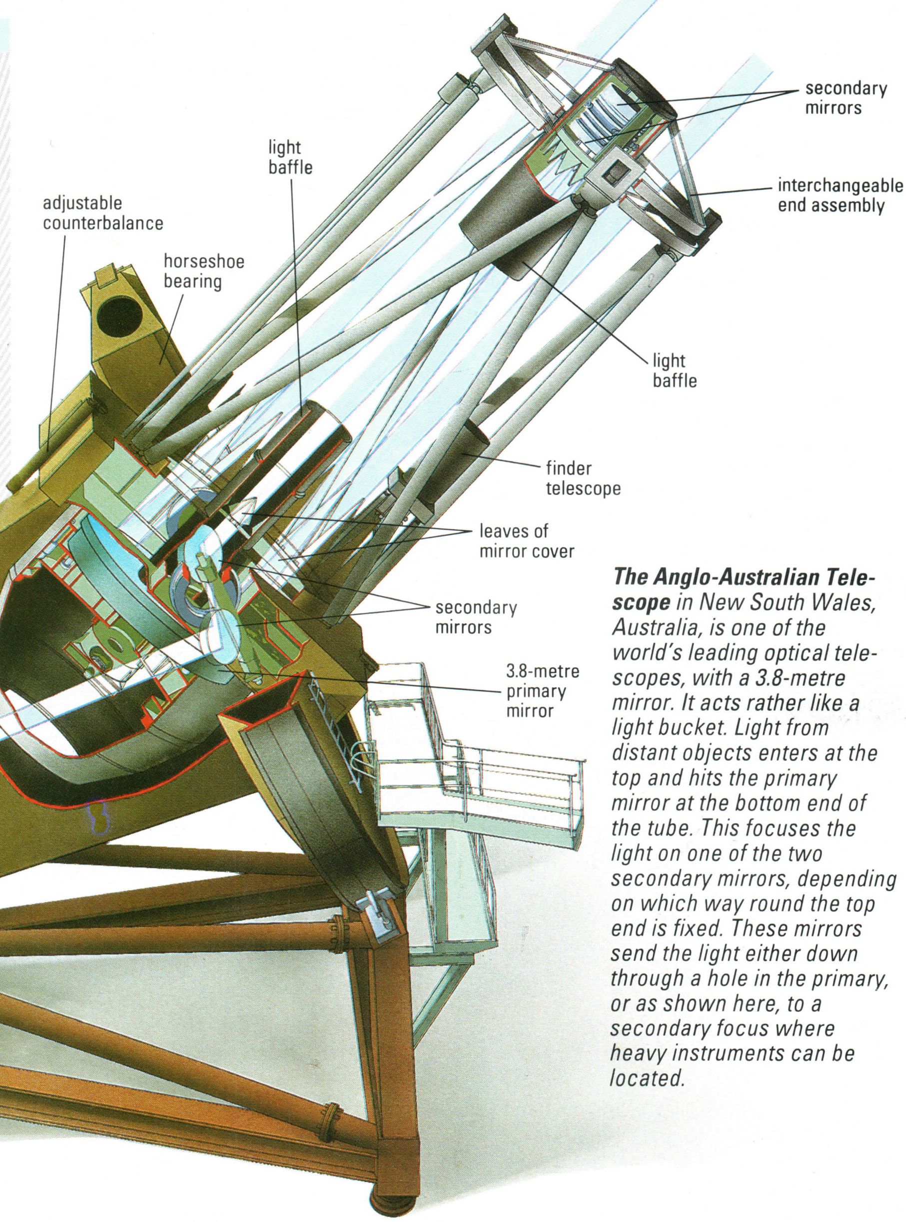

Ronald Royer/SPL

***Orion Nebula**, a glowing cloud of gas, taken using a long exposure photograph. This builds up the light from the faintest parts, making them easily visible.*

MULTIPLE VISION


David Parker/SPL

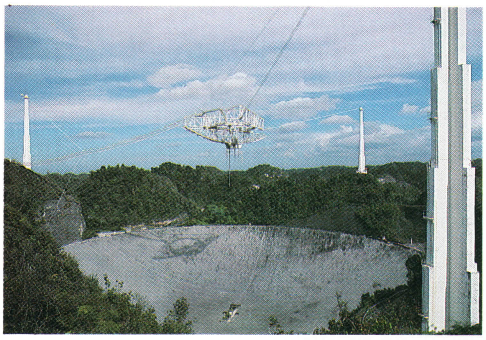
The Multiple Mirror Telescope (MMT) in Arizona, USA, uses six, 1.8-metre mirrors to create an image as good as a single, 4.5-metre mirror. A new single mirror, 6.5 metres across, is to replace the six mirrors in 1994. New techniques have made possible giant mirrors, up to 8.4 metres in diameter.



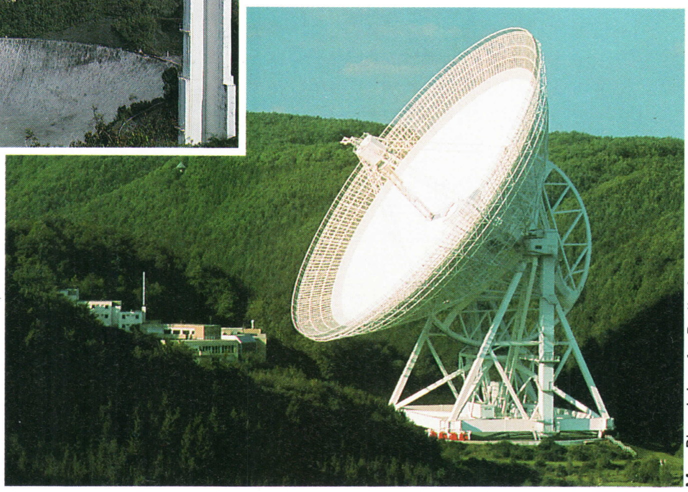
***The Anglo-Australian Telescope** in New South Wales, Australia, is one of the world's leading optical telescopes, with a 3.8-metre mirror. It acts rather like a light bucket. Light from distant objects enters at the top and hits the primary mirror at the bottom end of the tube. This focuses the light on one of the two secondary mirrors, depending on which way round the top end is fixed. These mirrors send the light either down through a hole in the primary, or as shown here, to a secondary focus where heavy instruments can be located.*

April 1990, is the first large optical telescope in space. Its 2.4-metre mirror gives the best views of the Universe yet, as it does not have to observe through Earth's polluted atmosphere.

A major new 'window' on the sky opened up when it was found that radio waves arrive at the Earth from space. Since radio wavelengths range from about a thousand to many millions of times those of light waves, the collecting dish of a radio telescope has to be much wider than the mirror of an optical telescope. Only in this way can astronomers distinguish reasonably fine detail in the objects they study.



Hencoup Enterprises/SPL



Max-Planck-Inst for Radio Astronomy/SPL

The giant dish *of Effelsberg radio telescope in Germany. But at 100 metres, it is almost dwarfed by the 300 metre dish set in a natural hollow near Arecibo in Puerto Rico (inset).*

To focus even more sharply on radio-emitting objects in space, the observations from widely spaced radio telescopes are combined to yield a much more finely detailed view of the radio sky. Radio telescopes in different continents can be linked in this way.

Heart of the galaxy

Radio astronomers have been able, among other things, to peer beyond the dust that hides the mysterious core of our Galaxy from the view of the optical astronomer.

Most kinds of radiation, other than ordinary light and radio waves, are prevented from reaching the ground by the Earth's atmosphere. To detect and decode these cosmic messages, special instruments have to be sent into space aboard orbiting satellites.

Spaceborne x-ray detectors, for instance, have recently given us glimpses of extremely violent parts of the Universe. One especially powerful source of x-rays, known as Cygnus X-1, is almost certainly due to fantastically hot matter plunging into a star-sized black hole, the remnant of a star that blew up as a supernova.

The infra-red sky

Observations made by the Infra-red Astronomical Satellite, IRAS, have given astronomers their first clear picture of the infra-red sky. (Infra-red radiation has wavelengths longer than visible light. Heat radiation is one kind of infra-red light). IRAS has found glowing rings of material circling some nearby stars, such as Vega and Fomalhaut. Within these dusty rings, some astronomers suspect, new systems of planets are being formed.

Just amazing!

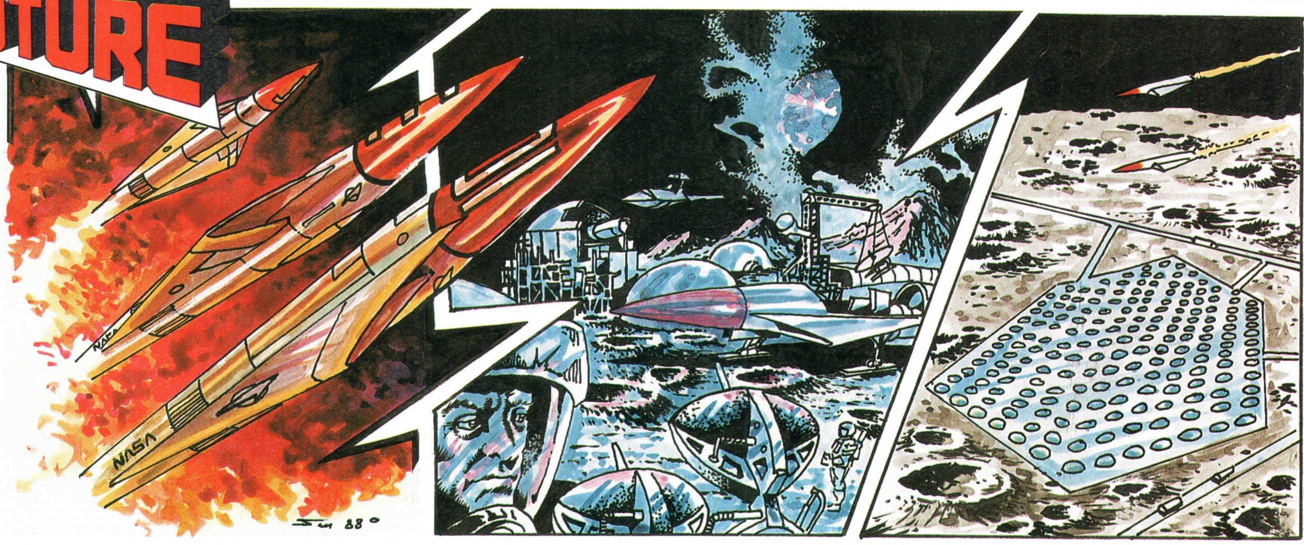
CANDLE POWER

A SET OF 36 MIRRORS COMBINE TO MAKE THE WORLD'S BIGGEST OPTICAL TELESCOPE, 10 METRES ACROSS, ON HAWAII. KNOWN AS THE KECK TELESCOPE, IT IS POWERFUL ENOUGH TO PICK UP THE LIGHT OF A SINGLE CANDLE 70,000 KM AWAY.

Paul Raymonde

INTO THE FUTURE

PROJECT CYCLOPS



Allan Burrows

▲ As 'electronic smog' – stray radio and TV signals – becomes worse on Earth, radio astronomers may be forced to take their equipment into space.

▲ Radio observatories could be built on the far side of the Moon, the only place in the solar system shielded from Earth's electromagnetic interference.

▲ An array of hundreds of radio telescopes, called Project Cyclops, could probe the Universe to enormous distances, or pick up messages from alien civilizations.

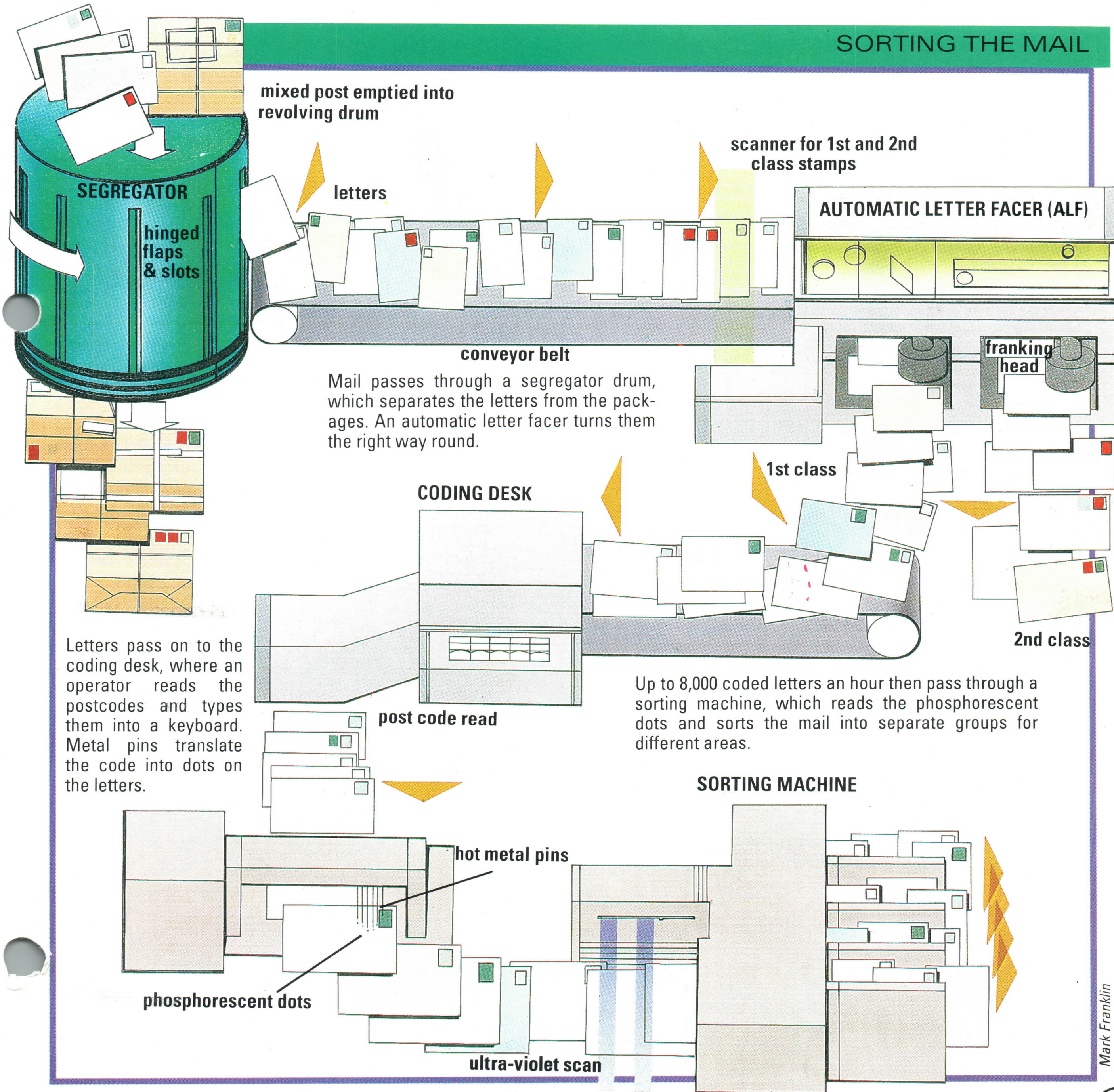
ELECTRONIC MAIL

WHEN SCIENCE-FICTION writer Arthur C. Clarke began work on the film '2010: Odyssey Two' he faced a big obstacle. Clarke lives in Sri Lanka and hates to travel. He had to work with the film's director and screenwriter, Peter Hyams, based in Los Angeles.

How could these two men collaborate closely when they were based nearly 20,000 km apart?

Ordinary mail would have been hopelessly slow. The time difference, and the busy schedules of the men made phone calls impractical. But Clarke and Hyams solved their communications problem by using electronic mail, or e-mail — a remarkable way of sending messages by computer. A message typed by one of the men on his personal computer was sent over the international phone network and stored in a large computer in the other country. The other man then used his own personal computer to 'read' this message, using a local phone link at any convenient time.

SORTING THE MAIL



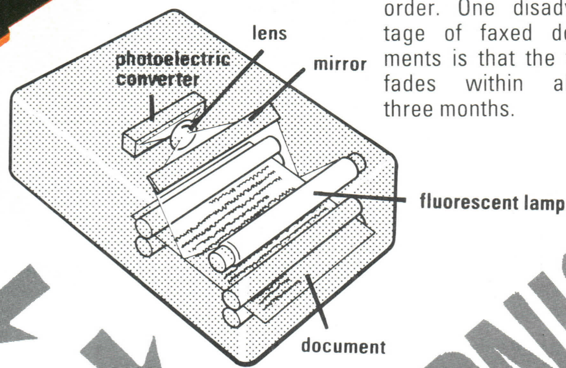
Mail passes through a segregator drum, which separates the letters from the packages. An automatic letter facer turns them the right way round.

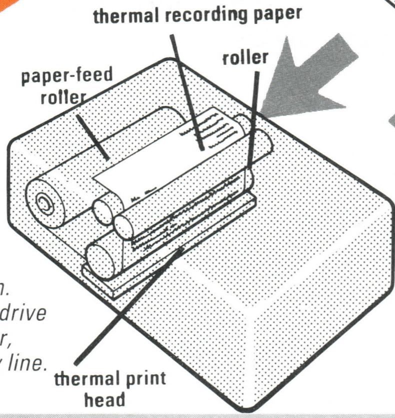
Letters pass on to the coding desk, where an operator reads the postcodes and types them into a keyboard. Metal pins translate the code into dots on the letters.

Up to 8,000 coded letters an hour then pass through a sorting machine, which reads the phosphorescent dots and sorts the mail into separate groups for different areas.

Mark Franklin

Fax machines are now an invaluable addition to the modern office, but they are also becoming a common sight in the high street. Many printing and photocopying shops act as fax bureaux, sending and receiving private documents to order. One disadvantage of faxed documents is that the type fades within about three months.





A facsimile machine, or fax, changes the image on a document into a series of electrical pulses. Light from the paper is focused on to a light-sensitive cell, which changes light variations into pulses that travel through the phone system. The receiving fax uses these to drive a thermal or electrostatic printer, which copies the original line by line.

While new methods of communicating are partly taking over from conventional mail, the postal agencies are bringing in modern technology to speed up their service. Automatic sorting is one example.

Coding the post

At a letter-sorting office each incoming envelope is marked with a machine-readable code indicating where it is to be sent. The code consists of a pattern of phosphor dots that glow when invisible ultraviolet light is shone on them.

An operator usually reads each address, as a machine presents the envelope to him, and types out the code. But in some sorting offices those letters that have typewritten addresses are sent to machines that can read printed characters. These machines then mark on the phosphor dot patterns, and sorting machines route the letter to the next stage of its journey.

Instant messages

Even without using computers, information can be 'posted' today almost instantly between places that may be very far apart. Any document, whether it is printed or handwritten text, or even an illustration, can be sent over the phone line via facsimile machines. Telex machines (teleprinters) also use the phone network. These transmit typed messages rapidly from one place to another.

Many companies now provide their employees with individual computer terminals, or 'workstations', so they can pass information instantly and easily from desk to desk and from office to office, saving the company both time and money.

Methods for receiving electronic messages over the telephone lines are available in the home, even to people who do not own computers or fax machines. A subscriber to a 'viewdata' service uses an ordinary TV set. He can call up any one of hundreds of thousands of 'pages' of information that are regularly added to and updated.

Viewdata

Weather forecasts, road traffic reports, aircraft departures and arrivals, sports results and news, financial information, entertainments guides and many other information services can all be provided on viewdata.

All this information is stored in the memory of a powerful central computer. It can be contacted by any subscriber to the viewdata service simply by dialling its telephone number on a keypad. An index displayed on the television screen shows the subscriber which buttons to press in order to obtain the information that he or she requires.

In Britain, British Telecom run a viewdata service called Prestel. Besides obtaining information, subscribers with a suitable personal computer can use Prestel's electronic mail service to leave messages for other subscribers in the main computer's memory.

E-mail works well for transmitting typed messages. But when the information to be sent is in ordinary handwriting, or contains a mixture of text and illustrations, a facsimile, or fax machine can be used to transmit it through the telephone system to another fax machine.

At the sending end, the machine changes the image on the document into electrical signals. At the receiving end, the signals are used to make a printer produce a replica of the original document.

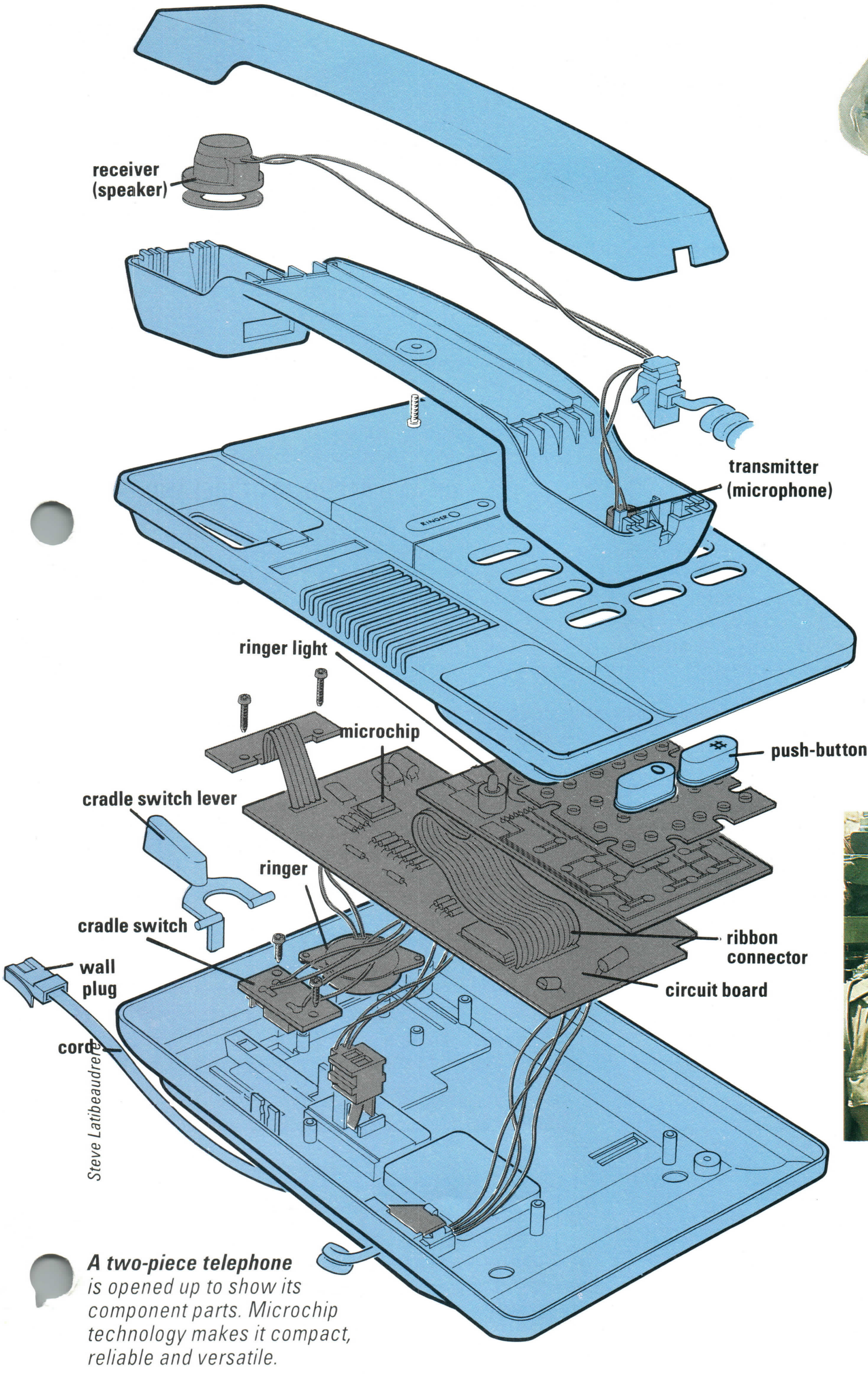
Using a radio link, facsimile copies may also be sent to motor vehicles, ships and aircraft, a facility often used by the armed forces.

THE TELEPHONE REVOLUTION

DIGITAL SYSTEMS CELLULAR PHONES

OPTICAL FIBRES


Philips



Steve Latibeaudiere

A two-piece telephone *is opened up to show its component parts. Microchip technology makes it compact, reliable and versatile.*

THE WORD 'TELEPHONE' means literally 'sounds from afar'. But today's telephone system can do much more than just carry our voices around the world. Computer data, pages of text, and even handwritten notes or complex artwork can all be sent down modern telephone lines in a matter of seconds.

New types of phone are now available with electronic memories that can store frequently used numbers, automatically re-dial an engaged line, or even transfer incoming calls to another number when a person is away.

Cordless phones that use radio waves instead of cables are also becoming popular, and people with mobile phones fitted in their cars can make calls to any part of the world by means of radio networks, just as if they were sitting at home or in their office. Most remarkable of all, in some areas, phones are being linked not by ordinary cable, or even by radio waves, but by slender strands of glass along which messages travel by laser light.

When you talk on the phone, your vocal chords set up sound waves in


John Watney

The radio telephone*, once used mainly by military and emergency services, is now used by millions in a new form – the cordless telephone. In both types of equipment, messages are sent and received by radio to give mobility.*

Telefocus/British Telecom

***A translation** system developed by British Telecom. The computer displays what it thinks the speaker has said. When the speaker gives confirmation, the translation is sent.*

***An answering** machine records callers' messages when the owner is elsewhere. He can hear calls by dialling his number and holding a remote control bleeper (top) to the mouthpiece. This has a pre-set tone that activates the tape to rewind and play.*

Jarome Yeats/SPL

the air. As these sound waves enter the mouthpiece of your phone, they are transformed by a small microphone into electrical waves of a matching shape. The waves of electricity then speed along cables in the phone network and through exchanges, which direct them to the earpiece of the receiving phone. There a miniature loudspeaker converts the electrical waves back again into the sound of your voice.

Digital system

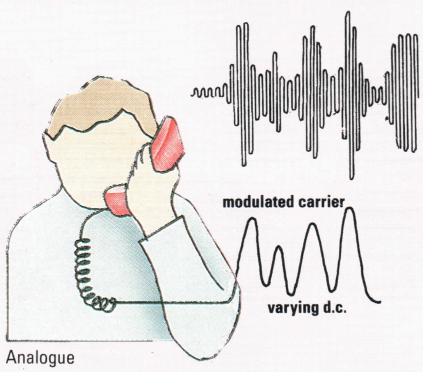
In years to come, phones will work in a different way. The present system is called analogue transmission because the electrical waves are analogous, or similar, to the spoken sound waves. But an increasingly important task of the phone network is to carry data between computers and other electronic machines. Computers operate using digital signals rather than analogue, so that communication between computers would be greatly improved if the phone system itself were to be made digital.

In a digital phone, your voice would first be changed into an electrical wave as before. But then the height of this wave would be sampled thousands of times a second to yield a series of numbers. Finally, these numbers would be turned into a stream of electric pulses — on/off binary digits, or 'bits' — which would then travel through the telephone network. Digital circuits are generally more reliable than analogue circuits and the effects of interference and circuit noise are more easy to eliminate from digital signals.

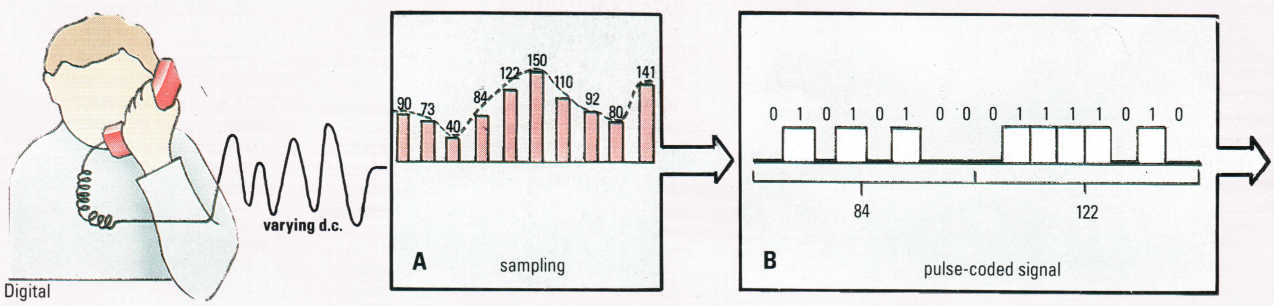
Already, many exchanges have been fully computerized and even long-distance trunk lines are on the digital system.

Modern exchanges equipped with powerful micro-electronic circuitry, can provide a wealth of new services, too, including voice synthesis. From an electronically stored library of responses, a caller can be given directory assistance, information on cost of calls, or any other

ANALOGUE vs DIGITAL SIGNALS

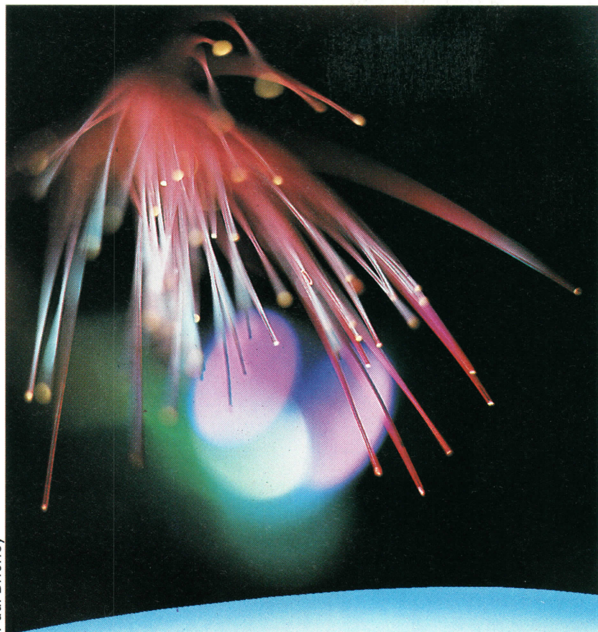


Most telephones still use analogue signals. The signal from the telephone to the exchange consists of a varying direct current (d.c.). At the exchange, the sound signal can be used to modulate (vary) a high-frequency alternating current (a.c.) 'carrier' signal. This is economical since many carriers can be sent along the same cable. In the newer digital systems, the current from the phone is 'sampled' 8,000 times per second (**A**). Each time its strength is measured as a number ranging from 0 to 255. These numbers are sent along the line in 'binary' form, using only the digits 0 to 1 (**B**). Each 1 is represented by a pulse, each 0 by a space. At the other end, the information is reconstructed as an analogue signal and turned into sound.



***Hair-thin** optical fibres can carry thousands of simultaneous phone conversations. The light waves that pass along each of these fibres can be seen glowing at the tips.*

***Light waves** bounce off the interface between the core and the outer 'cladding' of an optical fibre. The core is typically 1/20 mm across, but can be as narrow as 1/1000 mm – roughly equal to the wavelength of light being used.*



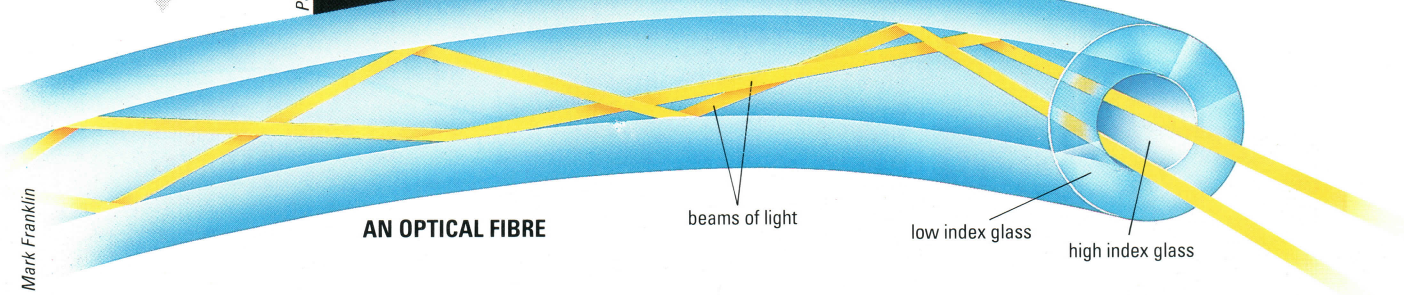
Paul Brierley

phone number, the signal enters the radio network and then travels from cell to cell, guided by computers, until it reaches the one with the receiving phone in it. A transmitting aerial linked to the cellular phone – perhaps on the roof of a car – is used to transmit a reply.

Radio phones are already available on some trains and are likely to become more and more common on all forms of public transport in the future. Soon, wherever you happen to be – on an inter-city train, a long-distance bus, or plane – you will have the facility to make a trans-Atlantic phone call to anywhere in the world.

Optically speaking

Most telephone calls today travel as electrical waves along thick copper



AN OPTICAL FIBRE

Mark Franklin

messages that may be helpful. In the more remote future, computers at an exchange may even be able to translate automatically the words spoken in one language to those of another.

Phones on the move

A big drawback of an ordinary phone is that it compels you to be in a certain place while you are using it. Think of how many thousands of calls must arrive every day just as someone is about to step into the bath, take a cake out of the oven, or watch a crucial moment in some televized game of sport. Now there is a way to take calls more conveniently – the cordless phone, a phone that you can carry around the house.

This kind of short-range radio phone relies on an adaptor fixed to a conventional telephone. The electrical waves of incoming calls are transformed by the adaptor into radio waves, and then sent to the cordless phone, wherever it happens to be – in the living room, the kitchen, or even the garden. In return, words spoken into the radio phone create radio waves that, upon being picked up by the adaptor, are sent back along the phone line in the normal way.

Cellular phones

Over a range of about 50 metres, such a phone works perfectly well. But it could hardly serve the needs of a businessman, for example, driving along in his car who has to stay constantly in touch with his company headquarters. Nor those of a heart surgeon who must be contacted without delay in an emergency or to perform a transplant operation. For people like these, another recent development – the cellular phone – has brought the ideal solution.

Set up around most of Britain now is an overlapping network of computer-controlled radio transmitters. Each of these covers an area around it called a cell. When a call goes out to someone with a cellular

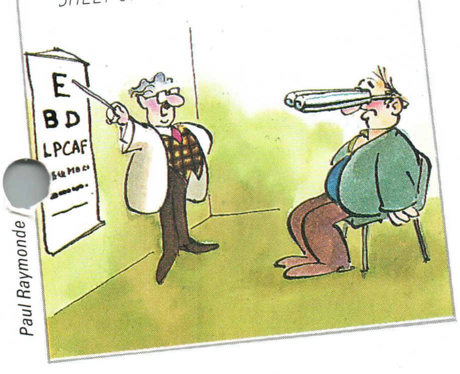
cables, either buried in the ground or strung out in the air between poles. Gradually, though, the old copper cables are being replaced by bundles of very fine glass strands called optical fibres. In these, phone messages are transmitted not as electricity, but as tiny, bright flashes of light.

A bundle of optical fibres, no thicker than your finger, can carry 10,000 phone calls at once – more than the capacity of a copper cable

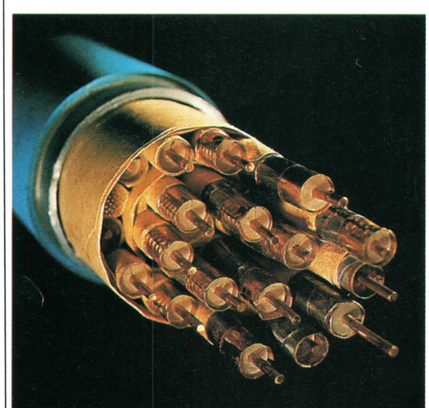
Just amazing!

SIGHT FANTASTIC

OPTICAL FIBRES ARE MADE FROM A SPECIAL TYPE OF GLASS THAT IS SO CLEAR, YOU COULD SEE THROUGH A SHEET OF IT 35 KM THICK.



Paul Raymonde



Paul Brierley

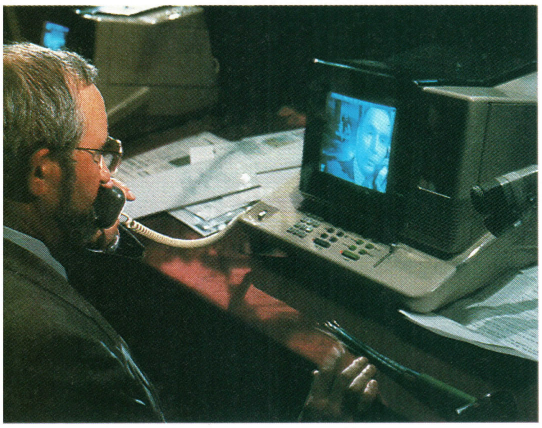
***Co-axial cables** carry thousands of phone conversations on a high-frequency signal. Nearly 20 'co-ax' cables are bound together into a long-distance cable. Each co-ax cable consists of a central copper wire surrounded by a copper sleeve. The signal is boosted by amplifiers every few kilometres.*

WATCHING YOUR MONEY

Telegraph Colour Library

A viewdata attachment turns your telephone and TV set into a terminal for a powerful computer. One of the many services you can get is personal banking. Here, a 'menu' of bank services is superimposed on a TV programme. If the user presses, say, 3 on his keypad, a signal is sent over the phone line to the computer. His bank balance is then flashed up on the TV screen.

***The videophone** has been under development by scientists since the early 1960s. But even though the technology now exists for a domestic network, the immense costs involved give it a major disadvantage.*



Frank Spooner Pictures

as wide as your arm. Each of these calls, having first been converted from ordinary electrical waves, passes along the glass fibres as pulses of light generated by a laser chip or an LED (light-emitting diode). At the receiving end, the light signals are once again turned into waves of electricity.

Developed in the 1960s, optical fibres can be coiled, bent and twisted just as if they were ordinary wire. Each fibre consists of a core of very pure glass along which the light signals travel. If the light tries to escape from the sides of the tube it meets an outer cladding of a different kind of glass that bounces the light back into the core again. A phone message travelling as a beam of light suffers no interference from stray electric fields. More importantly, with data security now such a major issue, a call carried as light waves is difficult to tap.

Almost without us realizing it, the global phone network is changing in remarkable ways. New stretches of optical fibre cable are being laid down in the United States, Britain and other countries each year. More and more calls abroad are travelling, not by undersea cable as before, but via powerful communications satellites perched high in Earth orbit. And increasingly, new electronic devices are being used to send information by telephone all across the world.

At your service

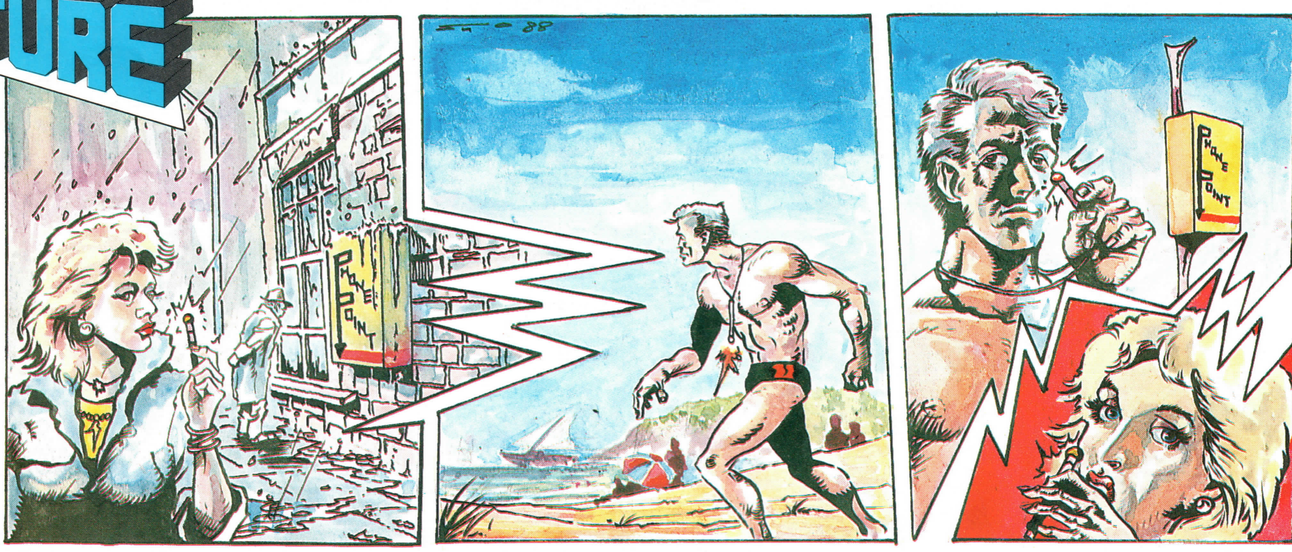
With just a small personal computer, linked by a modem to the phone, it is now a simple matter to access great libraries of information stored electronically. Known as databases, these libraries may specialize in certain technical subjects or contain general information of use to the ordinary person at home.

As well as computers, devices such as fax machines can communicate by phone. With a fax machine any sort of document or picture can be scanned electronically and its contents relayed by phone to a similar device where an exact copy of the original is printed out.

The telephone's role in alerting emergency services is well known. But now, at the first sign of trouble, people fitted with pacemakers are able to place a monitoring device over their chest, which can pick up very faint signals coming from the pacemaker and heart. Plugged into an ordinary telephone, it can then send these signals to the doctor's office or to a computer at a hospital some distance away. After the computer has compared the signals, the doctor can decide if the patient needs further treatment.

INTO THE FUTURE

KEEPING IN TOUCH

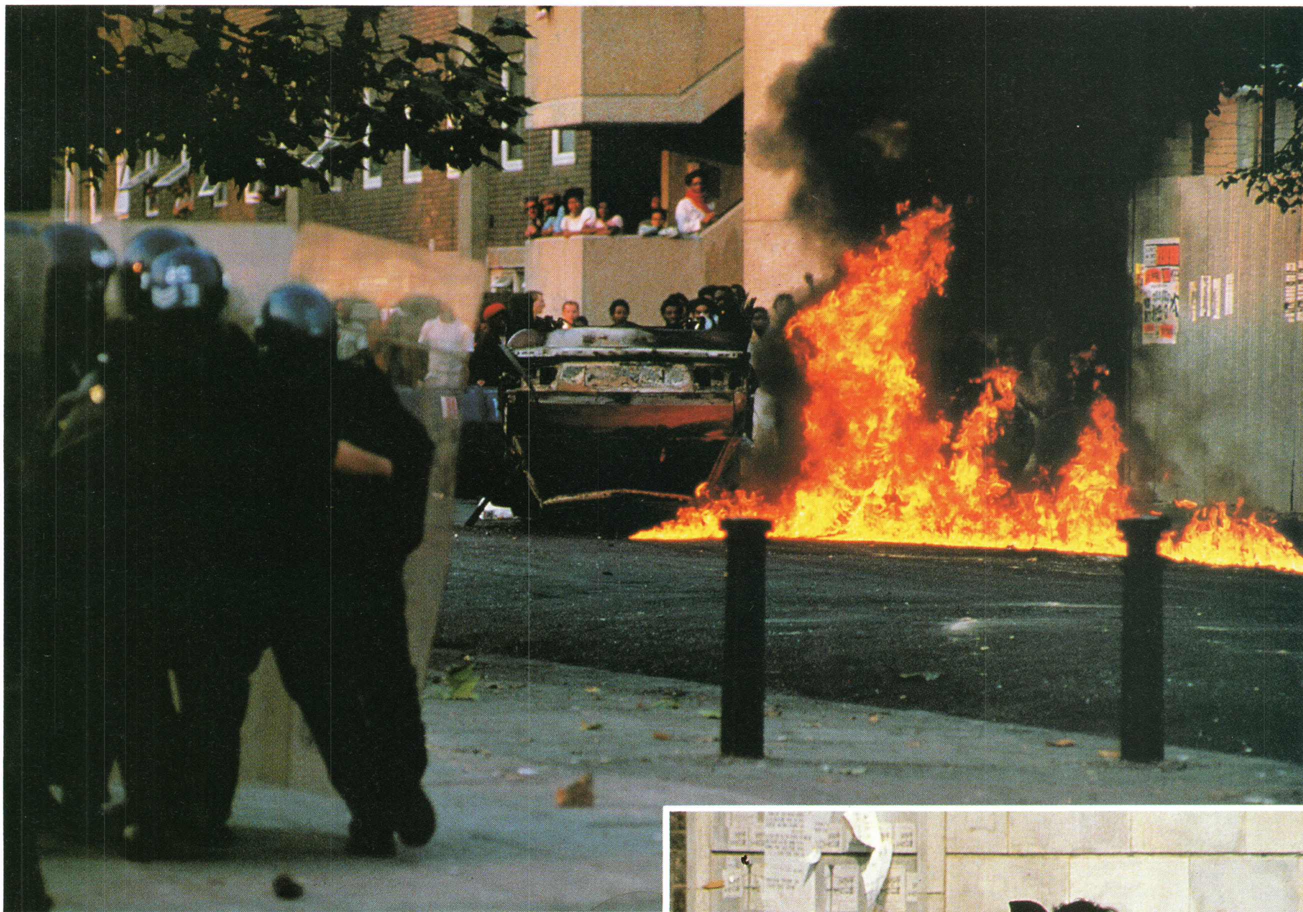


Alan Burrows

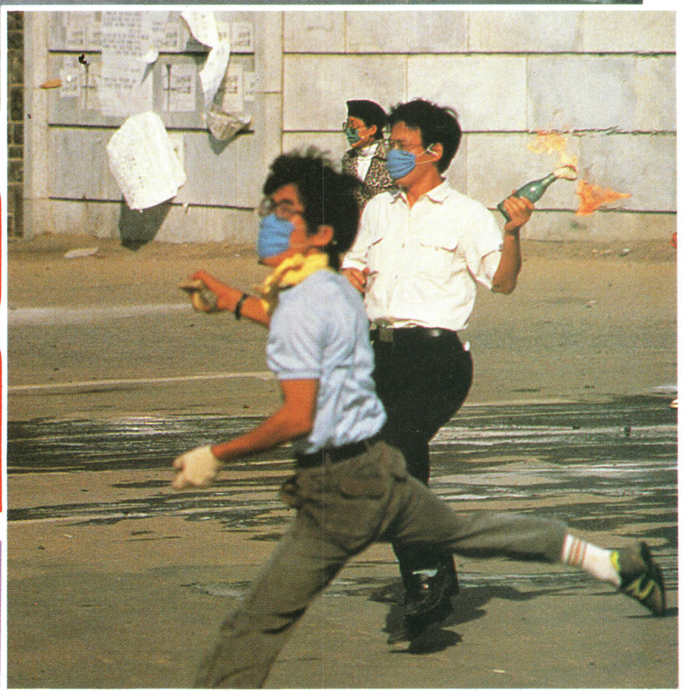
▲ *Portable phones may soon be in use everywhere. The user will need to be near a public 'callpoint', which picks up radio signals from the portable phone.*

▲ *Wherever he is, the person being called will be alerted by the radio pager built into his own portable phone, which will display the name and phone number of the caller.*

▲ *When he gets close to the closest callpoint, he will be able to hold a normal phone conversation with the person calling him with no outside interference.*



Rex Features



DANGER PATROL

A POLICEMAN WAS HACKED to death during a riot at Broadwater Farm Estate in Tottenham, London, on 7 October 1985. After a night of violence, 81 people had been rushed to hospital – 58 were police officers.

During violent riots, the police face a daunting array of weapons – iron bars, chunks of paving stone, bottles, petrol bombs and even shotguns. The need to provide the police with better protection than a helmet and a truncheon has led to the introduction of a variety of new riot control equipment.

Gas is a popular means of crowd control in many European countries. CS gas is faster acting and stronger in its impact than conventional tear gas (CN gas). Normally non-lethal, CS makes its victims feel as if they have been attacked with pepper. Exposure to thick clouds of the gas leads to coughing, vomiting and skin irritation, making any rioter incapable of causing further trouble.

Like other riot weapons, however, CS gas has its drawbacks: wind direction can blow it badly off course, and people suffering from respiratory problems could choke to death. Also, many rioters have realized that the gas can be overcome by holding a cloth soaked in vinegar and water over the face.

__Violent demonstrations__ and riots were a disturbing feature of the 1980s. British police sheltered behind shields during the 1981 Brixton riots (top). In South Korea, rebellious students hurled stones and petrol bombs at the authorities (above).

The water cannon is an armoured truck carrying hoses that send out jets of water under high pressure. The water can be mixed with vegetable dye, which turns the riot-

Short Brothers PLC

***The Shorland S.55** armoured personnel vehicle carries an eight-man crew. It is designed for the rapid deployment of security forces in high-risk areas, and has ports for anti-riot and sub-machine guns. Guttering below the windscreen diverts burning fuel from petrol bombs straight to the ground.*

ers green or blue, making the follow up and arrest of the troublemakers easier. Water cannons, however, have one major disadvantage – they can run out of water before the riot ends, leaving the vehicle open to hijacking.

Armoured vehicles

In the CIS, police use tanks to intimidate rioters, but control can be more effective if the police keep a low profile. The Shorland armoured vehicles have become a successful export from the UK. Based on the Land Rover, they have a makrolon polycarbonate skin and steel grills fixed to the windows. Shorlands are easier to drive and control in narrow city streets than tracked vehicles.

In the UK, the police try to quell riots without using firearms, and there are a number of riot tactics presently in use. During the 1981 riots in Toxteth, Liverpool, the police favoured 'hot pursuit' tactics, which involved police vehicles being driven at speed towards rioters to disperse them. In one unfortunate incident, the police van mounted the pavement, killing a local resident.

To enable police to arrest the most violent of the demonstrators, 'snatch squads' are brought into action. A small number of specially selected officers rush out from behind the cover of heavily protected riot police and grab the chief troublemakers.

Lightly armed, the squad normally wear padded body armour made from kevlar, a tough lightweight material, originally developed for tyres. Kevlar will withstand all but a bullet from a high velocity rifle.

Protective clothing

The British riot police – the 900 strong Territorial Support Group (TSG) – wear fire resistant clothing as protection against petrol bombs. The material – Nomex – combines much of the strength of Kevlar, with a far higher melting point. The TSG's only weapon is a long truncheon – almost a metre in length.

Makrolon polycarbonate is one of the most important materials used for protecting the police. This clear, tough plastic was first developed for astronaut visors. When fitted as a protective helmet, it can withstand rocks thrown at short range and, although it may crack during a heavy assault, it does not shatter.

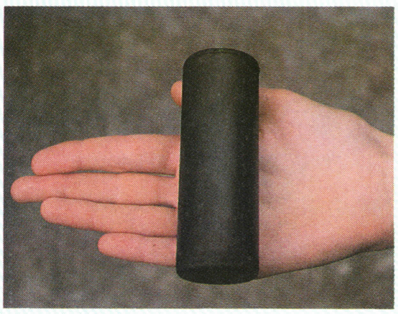
After plastic visors, two types of shield were introduced. The small shield is useful for mobile groups, while the one and a half metre shield gives full body protection.

Police at risk

The future of riot control is uncertain. Tests on disabling weapons such as electronic stun and laser guns and fast acting tranquillizer darts have proved inconclusive so

THE BATON ROUND

The rubber bullet, or baton round, was introduced in Northern Ireland in 1970 by the British Army. The bullet is 37 mm in diameter and weighs 142 g. Baton rounds are fired from weapons such as the Smith and Wesson Grenade Launcher, or the Arwen 37 multi-purpose gun (right). Fired low to hit the legs and torso, the bullet is intended to cause pain without severe injury. The main problem with the rubber bullet is that it tends to be inaccurate and, if fired at short range, it can be fatal. More recently, the plastic bullet has replaced the rubber one but, while it is more accurate, it is still potentially lethal.



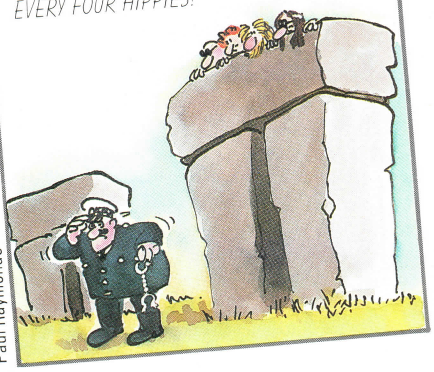
Pacemaker Press International

Royal Ordnance PLC/ British Aerospace

Just amazing!

MORNIN' ALL

WHEN 4,000 HIPPIES DESCENDED ON STONEHENGE TO CELEBRATE THE 1988 SUMMER SOLSTICE, THEY WERE MET BY MORE THAN 1,000 POLICEMEN FROM 17 FORCES – THAT'S ONE POLICEMAN FOR EVERY FOUR HIPPIES!



Paul Raymonde

far. If the police resist using violence to conquer violence, then they continue to put themselves at risk when faced with a rioting crowd.

The nerve of those police earmarked to combat riots, however, is matched only by the courage of the men in the bomb disposal unit.

Bomb disposal

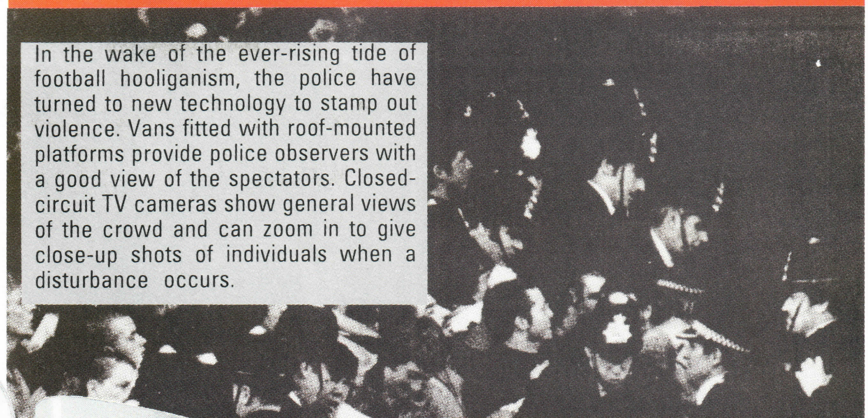
The battle between terrorist and bomb disposal expert is harsh. It is not unusual for a bomb to be planted as bait, and the surrounding area mined and perhaps covered by snipers, with the intention of putting the 'explosive ordnance disposal team' (EOD) out of action. The bomb may be fitted with devices to prevent it being moved or handled. It may also have sensitive electrical contact switches that react to vibration, and cause the bomb to explode if it is moved.

Anti-lift, anti-open and anti-disturbance switches became so common that a remote controlled bomb disposal robot was created to investigate suspected terrorist bombs.

The Wheelbarrow

'Wheelbarrow' is the name of a small remotely controlled tracked vehicle, which can be adapted to carry a number of devices. It has an articulated arm carrying a closed circuit television camera and a floodlight. This allows the Wheelbarrow to drive up to the bomb, and send a picture of the device back to the EOD team. It can also lift the

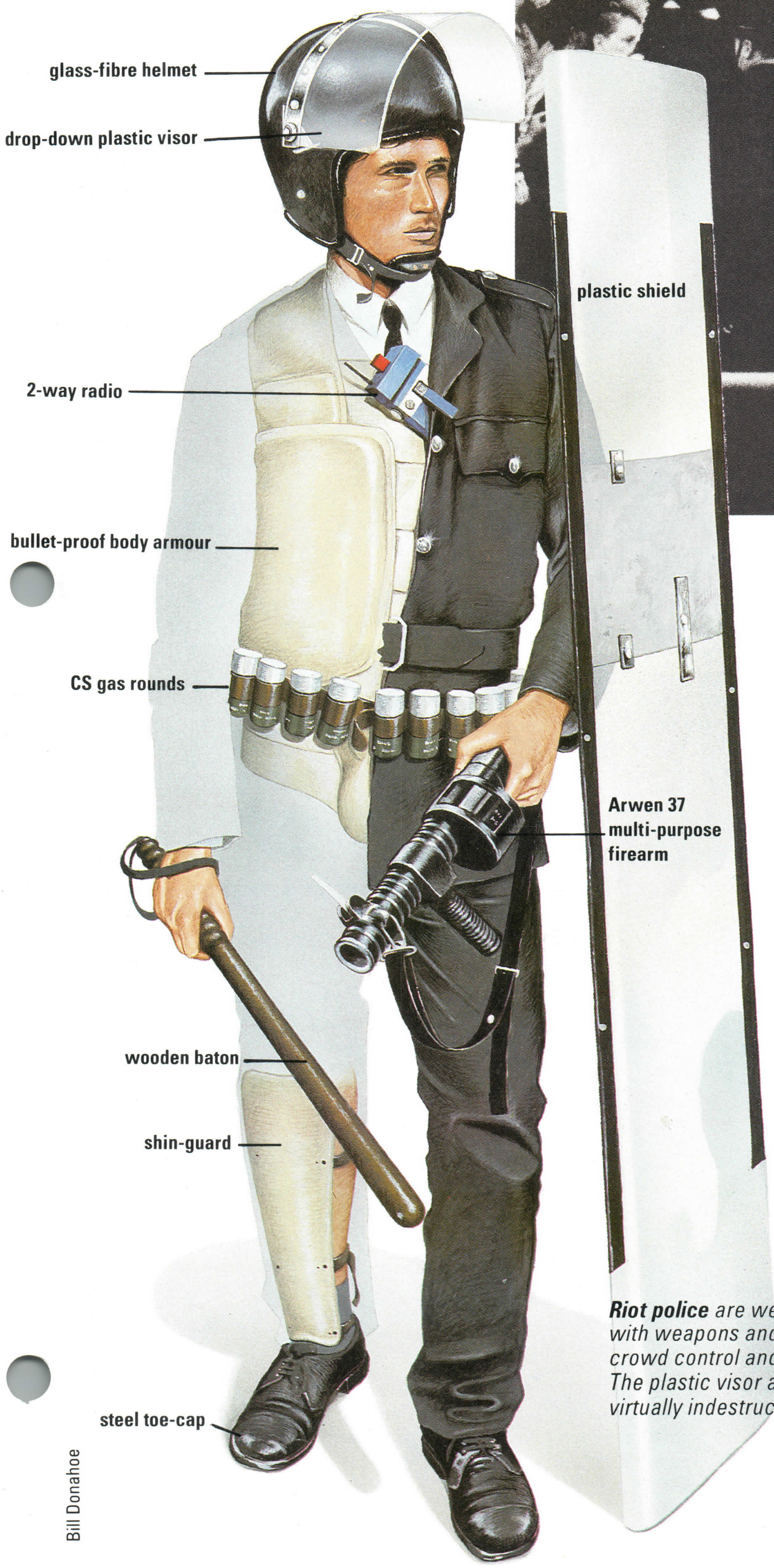
LOOKING FOR TROUBLE



In the wake of the ever-rising tide of football hooliganism, the police have turned to new technology to stamp out violence. Vans fitted with roof-mounted platforms provide police observers with a good view of the spectators. Closed-circuit TV cameras show general views of the crowd and can zoom in to give close-up shots of individuals when a disturbance occurs.

Popperfoto

Mike Goldwater/Network



***Riot police** are well equipped with weapons and armour for crowd control and close combat. The plastic visor and shield are virtually indestructible.*

Bill Donahoe

Pacemaker Press International

***An army robot,** known as the Wheelbarrow, investigates a bombed car in Belfast. Besides sending TV pictures of the wreckage to the bomb disposal team, the Wheelbarrow can also take x-ray equipment to the scene and return the exposed film. If another bomb is found, the machine can disarm it or move it to a safe place to be exploded.*

G. Sommer/Gamma/Frank Spooner Pictures

***The powerful jet** from a water cannon is an extremely effective means of breaking up groups of unruly demonstrators.*

bomb and turn it around if a closer inspection is necessary. Should the bomb explode, only the machine is damaged.

The Wheelbarrow can also fire a disrupter at the bomb. Either a special shotgun charge, or a shot of water discharged at high speed, rips into the bomb and severs electrical connections so quickly that it has no time to function.

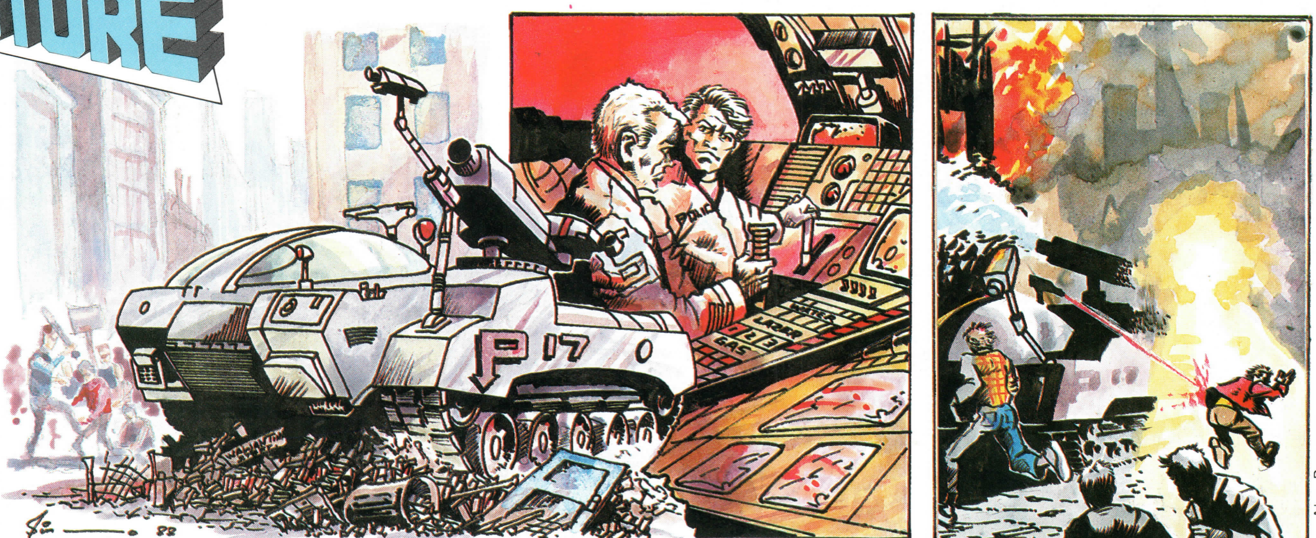
An improved version of Wheelbarrow known as 'Marauder', was also developed by the British Army. Marauder has longer tracks and, unlike Wheelbarrow, can even climb up stairs.

Some bombs, cannot be dealt with by remote control and have to be dismantled physically. Usually the first step in examining a bomb is to X-ray it. This reveals the internal mechanism. If the bomb is a simple device, the EOD team can slice open the outer container and cut the wires leading to the bomb detonator – the key component. Often the designer of the bomb will have incorporated some kind of booby trap to prevent it being tampered with. If the bomb uses a battery to power the detonator, then freezing the bomb will rend it inert and safe to be dismantled. Alternatively, a hole may be drilled in the bomb casing and electrically conducting foam pumped in. This shorts out the circuits and prevents detonation.

The bomb disposal expert can never relax. Each bomb presents problems as the terrorist tries to stay one jump ahead.

INTO THE FUTURE

AUTOMATIC RIOT CONTROL



Alan Burrows

▲ *Not much would stop a riot control vehicle of the future. It could be equipped with loudhailers, water cannon, knockout gas, stun guns and laser weapons.*

▲ *Inside the vehicle, operators could watch and record the pictures as they direct, focus and zoom the infra-red TV cameras mounted on the vehicle.*

▲ *One blast from a stun gun could temporarily paralyze a violent rioter, so that he could be taken into custody without violent resistance.*